Climate change policy and Canada's Inuit population: The importance of and opportunities for adaptation

For: Global Environmental Change

James D. Ford [1], Tristan Pearce[2], Frank Duerden[3], Chris Furgal[4], and Barry Smit[5]

[1] Dept. of Geography, McGill University, 805 Sherbrooke St W, Montreal, Quebec, H3A 2K6 CA, Mobile: 514-462-1846, Email: james.ford@mcgill.ca
[2]Dept. of Geography, University of Guelph, Guelph, Ontario, CA, Email: tpearce@uoguelph.ca
[3]Frank Duerden Consulting, 117 Kingsmount park Rd., Toronto, Ontario, CA
[4]Indigenous Environmental Studies Program, Trent University, Peterborough, Ontario, CA
[5]Dept. of Geography, University of Guelph, Guelph, Ontario, CA

Acknowledgements

We would like to thank Inuit of Canada for their continuing support of this research. This article benefited from contributions from Christina Goldhar, Tanya Smith, and Lea Berrang-Ford, and figure 1 was produced by Adam Bonnycastle. Funding for the research was provided by ArcticNet, SSHRC, Aurora Research Institute fellowship and research assistant programmes, Association of Canadian Universities for Northern Studies (ACUNS), Canadian Polar Commission Scholarship, the International Polar Year CAVIAR project, and the Nasivvik Centre for Inuit Health and Changing Environments.

Abstract

For Canada's Inuit population, climate change is challenging internationally established human rights and the specific rights of Inuit as stated in the Canadian Charter of Rights and Freedoms. Mitigation can help avoid 'runaway' climate change, adaptation can help reduce the negative effects of current and future climate change for Inuit populations, take advantage of new opportunities, and can be integrated into existing decision-making processes and policy goals. Adaptation is emerging as a priority area for Canadian and international action on climate change, and can help Inuit adapt to changes in climate that are now inevitable. We identify entry points where policy can support adaptation to the social, cultural, health, and economic effects of current and future climate change. These include supporting the teaching and transmission of environmental knowledge and land skills, enhancing and reviewing emergency management capability, ensuring the flexibility of resource management regimes, economic support to facilitate adaptation for groups with limited household income, increased research effort to identify short and long term risk factors and adaptive response options, protection of infrastructure, and promotion of awareness of climate change impacts and adaptation among policy makers. While these entry points are explored in a climate change context they have broader relevance for addressing social, economic, and cultural policy priorities in Canada's north.

Key words: Inuit, climate change, vulnerability, adaptation, policy, Canada, Nunavut, Inuvialuit Settlement Region, Nunatsiavut, Nunavik, climate policy

1 Introduction

There is strong evidence that human induced climate change is underway in the Canadian Arctic (Barber et al., 2008, IPCC, 2007b). Temperatures have been increasing at twice the global average, recent years have witnessed a dramatic reduction in summer sea ice cover and ice thickness, and extreme weather conditions appear to be increasing in both magnitude and frequency (ACIA, 2005, Barber et al., 2008, Comiso et al., 2008, Graversen et al., 2008, IPCC, 2007b, Min et al., 2008, Serreze et al., 2007). These climatic changes are having implications for Canada's Inuit population, many of whom depend on hunting and fishing for their livelihoods (ACIA, 2005, Furgal et al. , 2008, Furgal & Prowse 2008). Climate models indicate that climate change will be amplified in arctic regions (IPCC, 2007b, Lenton et al. , 2008, Serreze & Francis, , 2006) and communities, governments, and Inuit organizations have expressed their concern. Inuit political leaders have even argued that climate change is a fundamental human rights issue, compromising the ability of Inuit to practice and enjoy the benefits of their culture (Bravo, 2008, Crump, 2008, ICC, 2005). In this context, the question of what constitutes appropriate policy action on climate change for Inuit is becoming a prominent area for climate policy debate both in Canada and internationally (Furgal & Prowse, 2008, Health Canada, 2008b, Kelman and van Dam, 2008). Yet despite a proliferation of climate change research on impacts, adaptation, and vulnerability in Arctic regions in recent years, few studies have examined opportunities for practical policy initiatives for adaptation (Budreau and McBean, 2007, Ford, 2008b, Ford, 2009a, Ford & Furgal, 2009, Ford et al., 2007).

In this paper, we argue that adaptation to reduce vulnerability to climate change should be an immediate priority for Canada's Inuit population. We synthesize findings from peer reviewed literature and community research in which we are involved to identify adaptation needs and outline entry points for adaptation policy. A large array of possible options exist to support Inuit adaptation; we analyze how multiple levels of government in Canada can establish and strengthen conditions favorable for effective adaptation to help reduce the negative impacts of climate change on resource harvesting, travel, food systems, and community infrastructure. Our recommendations are of direct relevance to article 4 of the United Nations Framework Convention on Climate Change (FCCC), which stresses the importance of identifying measures to facilitate adequate adaptation, and are intended to support climate change policy development in Canada's northern regions. The focus on Inuit in this paper reflects the urgency of developing policy initiatives for this highly vulnerable segment of the Canadian and global population. At a broader level, the Inuit experience of climate change, the urgency of adaptation, and recommendations for policy entry points have relevance for indigenous peoples in general, particularly those whose culture and livelihoods are closely linked to land-based aspects of traditional lifestyles. We begin the paper by assessing the current status of Inuit in Canada and documenting the threat posed by climate change—a necessary first step to discussing policy response.

2 Canada's Inuit population

Inuit are indigenous peoples inhabiting Arctic and sub-Arctic regions of Canada, Alaska, Greenland, and Chukotka (Russia), numbering approximately 165 000 people (Young and Bjerregaard, 2008). In the 2006 census, 50 480 Canadians defined themselves as being Inuit

(Table 1), 24 635 of whom live in Canada's newest territory of Nunavut (Figure 1). The other 25 845 live primarily in three Inuit settlement regions: the Inuvialuit Settlement Region (ISR) in the Northwest Territories, Nunavik in the province of Quebec, and Nunatsiavut in the province of Newfoundland & Labrador (Figure 1). Together, Inuit administered regions (herein Inuit regions) cover a vast area – 31% of the Canadian landmass.

INSERT FIGURE 1 HERE

INSERT TABLE 1 HERE

The climate of Arctic Canada is characterized by very cold, long winters and short, cool summers, with the majority of the land surface area of the four Inuit regions continuous permafrost. Sea ice is an integral part of life in the Arctic. Depending on geographic location, the length of time at which the ocean is frozen varies from seven months in Nunatsiavut to nearly year long coverage in northern Nunavut. In many locations, the ice may exceed several meters in thickness, although distribution and thickness of sea ice are variable. The frozen ocean provides an important transportation link between communities, with few permanent paved roads in Inuit regions; however, it also acts as a barrier to boat transportation. The ice also provides a platform for culturally and economically important harvesting activities (Furgal & Prowse, 2008).

Most Inuit live in small, remote, coastal communities, with economies composed of waged employment and subsistence harvesting (Table 1) (Figure 1). The wage economy is largely based on public administration, resource extraction, and arts and crafts, with tourism also important in some regions. Many Inuit retain a close and intimate relationship with the environment and a strong knowledge base of their regional surroundings, with traditional foods derived from hunting and fishing having social and cultural importance, and continuing to supply principal elements of Inuit diet (Furgal and Prowse, 2008). Social, economic, and demographic characteristics of Inuit communities in Canada often mirror those in developing nations (Senécal and O'Sullivan, 2006) (Table 1). Communities are challenged by limited access to health services, low socio-economic status, high unemployment, crowded and poor-quality housing, concerns regarding basic services such as drinking water quality, and low educational achievement (AHDR, 2004, Furgal & Prowse, 2008, Seguin, 2008) (Table 1).

The Inuit population of Canada have experienced sweeping socio-cultural changes in the second half of the twentieth century, as former semi-nomadic hunting groups settled into centralized communities. Not all of these changes have been negative but many have been undesirable, transforming livelihoods and social interaction within a generation with the introduction of the waged economy, imposition of western governance and legal system, development of regulations concerning traditional lands and activities, compulsory schooling, introduction and predominance of the English language, rapid population growth, and the transition from traditional to modern bio-medicine (Damas, 2002, Tester & Irniq, 2008). Chronic problems affecting many Inuit settlements, including high suicide rate, substance abuse, and addiction, have been attributed to rapid change and the associated acculturative stress (AHDR, 2004, Healey and Meadows, 2007). It is within this context that Inuit communities will experience and respond to climate change, with social and economic conditions potentially predisposing communities to be adversely affected by a changing climate (Duerden, 2004, Ford, 2009a, Ford and Smit, 2004, Furgal and Prowse, 2008, Furgal and Seguin, 2006).

3 Climate change and Canadian Inuit

Inuit communities have been particularly susceptible to changing climatic conditions documented in the last decade due to their dependence on climate sensitive resources for livelihoods (Ford & Pearce et al., 2008, Furgal, 2008, Furgal and Prowse, 2008, IPCC, 2007a, Nickels et al., 2006, Pearce, 2009a, Tremblay et al., 2006). Compromised food security, increasing danger of engaging in traditional practices, and the inability to hunt at certain times of the year have been noted across northern Canada. Increasing sea levels, coastal erosion, and permafrost thaw are also threatening the viability of some Inuit settlements, damaging important heritage sites, and compromising municipal infrastructure and water supply (Furgal and Prowse, 2008, Larsen et al., 2008, Martin et al., 2007, Nickels et al., 2006). These changes could be classified as "dangerous" with average temperatures in parts of the Canadian Arctic exceeding the 2˚C threshold that is widely believed to represent dangerous interference with the climate system, with similar impacts noted in indigenous communities across the North American Arctic (Alessa, 2008, Alessa et al., 2008, Chapin et al., 2004, Huntington et al., 2007, White et al., 2007, Wolfe et al., 2007). Benefits have also been noted with climate change, including improved hunting opportunities with longer ice free summers, reduced exposure to the health effects of extreme cold, enhanced opportunities for economic development, and potential for commercial fisheries (ACIA, 2005, Barber et al., 2008, Ford, 2008c, Furgal, 2008, Nickels et al., 2006, Wenzel, 2009). The overall impacts of current and projected climate change will vary by location but are generally are believed be negative (Furgal and Prowse, 2008, IPCC, 2007a, Seguin, 2008). In this context, climate change is increasingly becoming a human rights issue (Crump, 2008, ICC, 2005).

4 Climate change policy in the context of Canada's North

4.1 Mitigation and adaptation

The United Nations Framework Convention on Climate Change (FCCC) outlines two key areas for climate policy, mitigation and adaptation, both of which are essential to climate policy in Canada's Inuit regions.

Firstly, the FCCC and its principal update the Kyoto Protocol legally obligates parties to "achieve, in accordance with the relevant provisions of the Convention, stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system," (Article 2). In Canada, a 6% reduction in emissions was negotiated by the federal government in Kyoto, although the government has since indicated it will not meet these targets. Territorial and provincial governments in Canada have also established their own programs to reduce emissions.

Secondly, adaptation, which seeks to develop measures to reduce or moderate the negative effects of climate change and take advantage of new opportunities, is an important component of the Framework Convention (FCCC, 1992). Article 4.1b, for example, commits parties to "formulate, implement …national and where appropriate, regional programmes containing measures to ….facilitate adequate adaptation to climate change," (FCCC, 1992). In Canada,

adaptation has been recognized at federal, provincial, and territorial levels (Ford et al., 2007). The federal government has made commitments to support adaptation and Natural Resources Canada recently released a national adaptation assessment (Lemmen et al., 2008). In Arctic Canada, policy makers have also been proactive in pushing adaptation onto the agenda in recent years (Ford et al., 2007). The federal department of Indian and Northern Affairs, for example, made a commitment to develop an Impacts and Adaptation Strategy, and has identified adaptation as priority in Canada's Northern Strategy (INAC, 2007). Moreover, Canada is playing a key role in the Arctic Council's "Vulnerability and Adaptation to Climate Change in the Arctic" project, which will contribute to identifying and sharing adaptation expertise, best practices and possible actions (Kelman and van Dam, 2008). Despite discussions about adaptation at federal, provincial, and territorial levels, however, Canada has made limited progress beyond statements of general principles (Ford, 2008b, c, Ford, 2009d, Ford et al., 2007, Newton et al., 2005). The political agenda on adaptation remains nascent, with an 'adaptation deficit' between what policies and research are needed to promote and support adaptation and what is currently available (Budreau and McBean, 2007, Ford, 2009a).

4.2 The increasing importance of adaptation

Mitigation is central to efforts to tackle climate change and lower emission futures will give Inuit and the ecosystems on which they depend more time to adapt. Indeed, "dangerous" climate change may already be occurring in Canada's Arctic regions, or will happen soon, thereby compelling Parties to the FCCC to act immediately through mitigation to avoid "dangerous anthropogenic interference with the climate system," (Article 2) (Ford, 2009a). Mitigation is particularly important for the Arctic because unabated or 'runaway' climate change could have potentially irreversible negative impacts (IPCC, 2007b). However, we argue that *adaptation* should become a central feature of climate change policy development for Canada's Inuit region, and a priority for Inuit political negotiations both domestically and internationally. Adaptation is needed to uphold domestic Inuit rights and to prevent internationally recognised human rights being compromised (Ford, 2009a).

Firstly, it is now accepted that some degree of climate change is inevitable, even if atmospheric concentrations of greenhouse gases were dramatically curtailed (IPCC, 2007b, Ramanathan and Feng, 2008, Schellnhuber, 2008, Wigely, 2005). Communities, regions, and economic sectors will therefore have to adapt to some degree of climate change, particularly in the Arctic which is sensitive to climate change (Ebi and Semenza, 2008, IPCC, 2007b, Schellnhuber et al., 2006, Stern, 2006). Moreover, it is widely recognized that climate change is already occurring in the Arctic with some impacts happening faster than previously considered, and that Inuit populations are vulnerable (IPCC, 2007a, b). The IPCC (2007a) has noted that developing adaptation strategies is critical for arctic regions, especially for those people living close to the environment (i.e. Inuit of Canada).

Secondly, adaptation offers a tangible way in which vulnerability to current and future climate change can be moderated and Inuit livelihoods strengthened. Indeed, we would argue – following Newton et al. (2005), Budreau and McBean (2007), and Ford (2009a) – that the current focus of climate policy in Canada's Arctic regions *primarily* on mitigation is misplaced on account of low populations, the absence of a sizable industrial base, limited consumption

levels in northern Canada, and current vulnerability to climate change. Reducing emissions in Inuit regions will have limited impact on the speed, magnitude, or effects of climate change. This is not to downplay mitigation – mitigation efforts can also reduce vulnerability to climatic risks and should be part of a coordinated policy response to climate change – but to *prioritise* adaptation where human and financial resources are limited and climate change impacts already documented (i.e. Inuit regions of Canada).

5 Adaptation policy research

To identify adaptation needs and inform the development of policies to reduce the negative impacts of climate change, it is crucial to identify and characterize vulnerability (Adger, 2006, Smit & Wandel, , 2006). Vulnerability can be thought of as the capacity to be wounded: it is a measure of the susceptibility to harm in a system in response to a stimulus or stimuli. In the case of climate change, the stimulus or stimuli are climate-related risks, and the system can range from an individual or household unit to the nation-state. It is widely accepted in the climate change literature that vulnerability is related to both exposure and sensitivity to climatic-risks and adaptive capacity to deal with those risks (IPCC, 2007a). The recognition of the role of adaptive capacity and sensitivity in vulnerability research emphasizes the importance of non-climatic factors – including sources of livelihoods, assets, access to resources, globalization, institutional networks, education, gender, race, ethnicity, and poverty – in amplifying or attenuating vulnerability alongside the nature of the climatic stress, and builds upon a long history of social science research in the natural hazards field (Blaikie et al., 1994, Hewitt, 1983, Sen, 1981). Poverty, for example, can increase household sensitivity to climatic stress by forcing people to engage in dangerous activities, while a lack of economic resources can constrain the ability of households to prevent, avoid, or recover from climatic hazards. These determinants of vulnerability are influenced by social, economic, cultural, and political conditions and processes operating at multiple scales over time and space, and change in these non-climatic conditions play an important role in determining vulnerability to climate change (Burton and Lim, 2005, Chapin et al., 2004, Ford and Smit, 2004, Keskitalo, 2008, 2009, O'Brien et al., 2007, 2004). Importantly, the emphasis of vulnerability research on multiple stresses also broadens the scope for adaptation policy to include initiatives to reduce sensitivity and exposure while increasing adaptive capacity.

In the climate change field in general, vulnerability science is a well established foci of research, with an expanding body of research operationalizing the concept of vulnerability and linking research to the policy process (Adger et al., 2001, Bouwer and Aerts, 2006, Burton and Lim, 2005, Leichenko and O'Brien, 2002, Pelling, 2002, Thomalla et al., 2006). However, as highlighted by the ACIA (2005), IPCC (2007a), and Ford and Furgal (2009), while there is an emerging body of scholarship on climate change vulnerability and resilience in the Arctic, and occasional studies addressing broad principles of adaptive management (Berkes, 2005, Berkes et al., 2007, Chapin, 2006, Chapin et al., 2006), few studies have examined specific entry points for adaptation policy. This is limiting the ability of governments, communities, and businesses in identifying opportunities for adaptation and moving forward on adaptation planning (ACIA, 2005, Ford, 2009a, Health Canada, 2008a).

6 Entry points for climate change adaptation policy in Canada's Inuit regions

In this section we outline how multiple levels of government in Canada (federal, territorial, regional, municipal) can establish or strengthen conditions favorable to reducing exposure and sensitivity to climate risks and enhancing adaptive capacity. Adaptation entry points are identified based on an understanding of the multiple determinants of vulnerability identified in research conducted by the authors in all Inuit regions of Canada, involving extensive interviews (>500) with community members, policy makers, and other stakeholders over the past decade (Duerden, 2004, Duerden and Beasley, 2006, Ford, 2006, Ford, 2009d, Ford, 2009b, Ford et al., 2006, Ford & Pearce et al., 2008, Ford et al., 2007, Ford & Smit et al., 2008, Furgal, 2008, Furgal et al., 2002, Furgal and Prowse, 2008, Furgal and Seguin, 2006, Pearce, 2005, 2009a, 2009b, Pearce et al., 2009, Pearce et al., 2006). Here we take the next step and highlight ways in which policy can (and in some cases is) address(ing) vulnerability. The synthesis of primary research is complemented by a review of scientific research and relevant grey literature pertaining to climate change vulnerability and adaptation in general and Inuit regions in particular. The review is utilized to add further detail on determinants of vulnerability and opportunities for adaptation. Table 2 summarizes these entry points.

INSERT TABLE 2 HERE

The policy entry points are organized according to how they can serve to maintain internationally recognized rights for Canadian Inuit in a changing climate, aiming to reduce vulnerability to current *and* future climate change. Specifically, the focus is on identifying opportunities for policy to reduce climate change vulnerabilities associated with resource harvesting, travel, food systems, and community infrastructure – key vulnerabilities identified by Inuit during research and policy discussion. Other sectors are beyond the scope of the paper. Importantly, the recommendations target key drivers of vulnerability for Inuit regions of Canada *as a whole*: community specific adaptation options are addressed elsewhere (Nickels et al., (2006) for communities in the four Inuit regions; Ford et al., (2007) in Nunavut; Lynch and Brunner (2007) in Alaska).

6.1 Promoting adaptation to the cultural effects of climate change

6.1.1 Affording adaptation

The right to practice and enjoy the benefits of one's culture (UN, 1948, article 27, UN, 2007, articles 11, 12, 13, 31) is threatened in Inuit regions as climate change reduces access to traditional hunting areas and compromises the ability for resource harvesting at certain times of the year (Berkes and Jolly, 2002, Bravo, 2008, Gearheard et al., 2006, Nickels et al., 2006, Pearce, 2009a). Inuit are not passive in the face of such change (Furgal and Prowse, 2008, Gearheard et al., 2006) and across northern Canada community members are autonomously adapting by utilizing new equipment to maintain access to hunting areas (Furgal and Prowse, 2008). More ice-free open water in the summer, for instance, is considered a benefit in many communities and people are using boats to take advantage of the new hunting opportunities (Ford & Smit et al., 2008, Nickels et al., 2006, Wenzel, 2009). At other times of the year when the ice is unsafe, All Terrain Vehicles (ATVs) are being used to bypass the frozen ocean

(Lafortune et al, , 2006, Pearce, 2005, Pearce et al., 2006, Tremblay et al., 2006). New trail networks which detour unsafe and impassable areas are also being developed to access hunting areas (Ford, 2009b, Laidler et al., 2009, Laidler and Ikummaq, 2008, Tremblay et al., 2006).

Adaptation involving changing resource use patterns and technology in response to environmental circumstances has defined the very nature of Inuit survival in the Arctic for millennia, as it has among many indigenous communities globally (Damas, 2002, Krupnik, 1993, Wenzel, 1991). In the contemporary setting, however, Inuit households, especially hunting households or those without wage earning members, often do not have the financial capacity to afford adaptations (Furgal and Prowse, 2008). ATVs and boats, for example, are often too expensive (Ford & Smit et al., 2008). Moreover, the costs of having to travel further and therefore use additional fuel often exceed financial means. As Ford et al (2008) and chapters in Riewe and Oakes (2006) argue, constrained access to adaptive options is exacerbating existing social inequalities between those with waged employment and those who depend on hunting for a living. In absence of financial support, future climate change could further increase the burden of adaptation on vulnerable groups.

Harvester support programs for those whose livelihoods are dependent on hunting are offered in all Inuit regions of Canada by regional governments and land claim institutions. These programs do not explicitly aim to reduce vulnerability to climatic conditions—they aim to maintain a strong and thriving traditional resource use sector—but they are important in providing a safety net for households, helping Inuit hunters recover from climate-related losses and providing financing for climate adaptations (Ford et al., 2007; Pearce et al. 2009a, b). Research has shown that harvester support has a positive impact on harvester viability and food production (Dorais, 1997, Kishigami, 2000, Myers et al., 2004). However, many of these programs are having difficulty meeting demands placed on them due to rising fuel and equipment costs, and the future of some programs is not secure (Aarluk Consulting., 2005, George, 2006b, INAC, 1996). There is also evidence that climate change is exacerbating shortcomings in funding allocation and future climate change will further increase pressure on harvester support programs (Ford et al., 2007). For those without access to other sources of income, harvester support could determine the sustainability of hunting in a changing climate.

Existing harvester support programs can be strengthened in several ways to increase their effectiveness in light of current and projected climate change. Firstly, enhanced financial support for harvester programs, targeted at helping Inuit afford to adapt would help Inuit maintain their ability to practice culturally important activities in a changing climate. Secondly, there is potential to strengthen the effectiveness of existing programs. Complexity and lack of knowledge of existing programs have been identified as constraining uptake among hunters, many of whom lack formal education (Aarluk Consulting., 2005). Better advertising and promotion to educate community members about harvester programs and promote their use could also increase program effectiveness. Thirdly, reviewing how funds are allocated to address concerns of nepotism within communities would help ensure that harvesters are accessing funding and strengthen community confidence in the programs (Pearce et al., 2009). Fourthly, current harvester support programs were not developed in the context of a changing climate. Reviewing current programs in light of new demands as a consequence of current and future climate change should be a priority for all Inuit regions.

6.1.2 Flexibility to adapt

Future climate change threatens to further compromise Inuit right to culture by affecting the migration timing, population health, quality of meat and furs, and availability of wildlife species important in subsistence-based hunting (Moore and Huntington, 2008). Ringed seal (*Phoca hispida*), for example, is an accessible source of year-round food in all northern Canada, is a principal item in Inuit diet, and is widely believed to be susceptible to climate change (Burek et al., 2008, Moore and Huntington, 2008, Wenzel, 2009). Caribou (*Rangifer tarandus*) and musk-ox (*Ovibos moschatus*) are also important food sources for Inuit communities, and are sensitive to winter freeze-thaw cycles which are expected to become more frequent with climate change (Miller and Gunn, 2003, Tews et al., 2007a, Tews et al., 2007b). Narwhal (*Monodon monoceros*) is important for communities in the eastern Arctic and migration timing and spatial distribution in the summer months could be affected by changing ice conditions in Baffin Bay (Laidre and Heide-Jorgensen, 2005, Laidre et al., 2008). Polar bear (*Ursus maritimus*) populations, which rely of sea ice for survival, could also be negatively affected by climate change and may even become extinct at the southern margins of their range (Derocher et al., 2004, McLoughlin et al., 2008, Schliebe et al., 2008). Negative effects on the health and availability of freshwater and saltwater fish species have also been recorded in the Canadian Arctic (Vilhjálmsson & HoelReist, 2006, 2005) and warmer temperatures are affecting the preparation of dry fish, the length of time that fish can spend netted in the water before spoiling, and optimal growing days (Andrachuk, 2008, Furgal and Prowse, 2008). The importance of these animals to Inuit goes beyond diet; the act of hunting, consuming, and sharing traditional foods is an important cultural activity, helping to produce and re-produce community social relations and defining what it means to be Inuit (Bravo, 2008, Damman et al., 2008, Gombay, 2007, Henshaw, 2007, Wenzel, 1991, 2005). Upholding the ability of Inuit to hunt culturally important animals – and healthy source of food – is therefore central to maintaining Inuit human rights.

Wildlife populations and migration patterns have always fluctuated in the Arctic. Flexibility in resource use has traditionally enabled Inuit to manage such variability and has underpinned Inuit adaptability to changes in climate documented in the last decade (Berkes and Jolly, 2002, Ford et al., 2006, Krupnik, 1993). Regulations, however, often constrain flexibility in harvesting by limiting how many species can be caught and specifying the timing at which hunting can take place (Collings, 1997, Wenzel, 2009). Moreover, Inuit communities and politicians are concerned that climate change will lead to increased pressure from the international community to strengthen existing quota systems and develop quotas for currently unregulated species (Clark et al., 2008, Dowsley and Wenzel, 2008, Dowsley, 2009, Tyrrell, 2007). As a result, controversies over how to manage climate change impacts on wildlife have emerged in recent years and have destabilized management and conservation of wildlife across northern Canada (Clark et al., 2008). The recent decision to list polar bears as an endangered species in the United States and the associated ban on US sport hunters importing polar bear skins acquired on sport hunts with Inuit guides in Canada maybe an indication of future conflict (Bird, 2008, Clark et al., 2008, Dowsley, 2009, George, 2006a, USFWS, 2008). Developing and altering quotas in response to outside pressures, which do not take into account local hunting needs and the ecology of harvesting, will almost certainly increase Inuit vulnerability to climate change, limiting the flexibility of hunting that has traditionally facilitated adaptive capacity, reducing options at the disposal of communities to adapt to future change, limiting the accountability and

transparency of wildlife management institutions, increasing confrontation, and having implications for economic well-being (and hence adaptive capacity) given the importance of traditional foods in Inuit diet (Armitage, 2005a, Armitage et al., 2008, Berkes et al., 2007, Clark et al., 2008, Wenzel, 2009). Ultimately, wildlife management regimes that fail to foster equitable access and human values, often fail in their conservation objectives too (Brunner, 2005, Clark et al., 2008).

Innovative co-management of renewable resources that integrates Inuit traditional knowledge, scientific understanding of population vulnerability to climate change, and allows Inuit to exercise their (legally defined) traditional rights is likely to increase adaptive capacity by maintaining some degree of resource use flexibility (Armitage et al., 2008, Berkes, 2005, Chapin et al., 2004, Clark et al., 2008, Dowsley, 2009). Research in Arctic and non-Arctic contexts, for instance, demonstrates that flexible, multi-level governance can help management systems deal with change by promoting the sharing of information between actors at different scales, linking scientific and traditional management systems, permitting greater opportunity to address conflicts over competing vision or goals, and providing an arena to solve conflict (Tompkins and Adger, 2004). Importantly, co-management may serve to strengthen trust between different actors in wildlife management; a positive development given the difficult decisions that might have to be made with climate change. Wildlife management in Inuit regions has progressed significantly in recent years, with new co-management bodies emerging in which federal and territorial/regional regulators and Inuit organizations decide annual harvest quotas (Berkes, 2005). This transition has been a turbulent process and while previous management systems have been improved, conflict still remains entrenched (Nadasdy, 2003, Natcher, 2005, Stevenson, 2006). In particular, differential power relations between actors and conflict over the role of science and traditional knowledge have been noted in communities as compromising effective decision making, ultimately resulting in management outcomes unsuitable to all parties (Armitage, 2005b, Clark et al., 2008).

Clark et al (2008) identify a number of policy options to reduce conflict over wildlife management in the context of multiple stresses and competing uses. In the short term they recommend focusing on sharing traditional and scientific knowledge in management decisions, appraisal and use of best-practice from other contexts, and the co-production of knowledge of the health and status of wildlife populations. In the long term they advocate emphasis on local and decentralized decision making to increase the adaptive capacity of regional and local scale management institutors. Moreover, in light of climate change, it is important that research (involving scientists and local hunters) highlights wildlife populations at risk, explores the sustainability of current wildlife harvesting, and develops response options in co-management bodies.

6.2 Promoting adaptation to the health and safety effects of climate change

6.2.1 Hazard epidemiology

Climate change is compromising the right of Inuit to lead healthy lives (UN, 2007 articles 21, 24; UN, 1948 article 25) by increasing the potential for injury and loss of life when harvesting and traveling and affecting psychological status through its cultural impacts (Corell, 2006, Ford,

2008a, Furgal, 2008, Seguin, 2008). Evidence suggests that climate-related accidents are increasing in Inuit communities in part due to changing climatic conditions, including thinning and earlier break-up of sea ice and more unpredictable weather (Ford & Pearce et al., 2008, Furgal and Prowse, 2008, Krupnik and Jolly, 2002, Laidler, 2006, Laidler et al., 2009, Laidler and Ikummaq, 2008, Nelson, 2003, Nickels et al., 2006)

6.2.1.1 Affording adaptation

Inuit are autonomously employing a number of strategies to minimize risks in a changing climate. Some hunters are using safety equipment such as satellite phones, global positioning systems (GPS), emergency beacons, VHF radios. and immersion suits when hunting (i.e. risk minimization strategies) and are utilizing available weather and ice forecasts to assess safety of using the land and sea ice at certain times of the year (i.e. risk avoidance strategies) (Bravo, 2008, Duerden et al., In Press, Ford et al., 2007, Furgal and Prowse, 2008, Gearheard et al., 2006, Pearce, 2009a, Pearce, 2009b). Small equipment funds are offered as part of harvester support programs to help people afford these new tools for anticipating and managing risks. In some communities, the local municipality, hunter's organization, and/or RCMP detachment will also loan safety equipment for short periods of time. The availability of funds and loan programs, however, is highly variable across Inuit regions and between communities. These expensive technologies, therefore, often remain inaccessible to Inuit who have limited access to financial means (Ford & Pearce et al., 2008, Pearce, 2005, Pearce et al., 2009, Pearce et al., 2006). As with the harvester support programs noted above, there is a need for enhanced financing to cover the purchase of safety equipment, training costs, and need to review current programs offered in light of climate change. Moreover, research has indicated that some technologies, such as GPS, that are being utilized to adapt to climate change may have unintended consequences and may increase sensitivity to climatic risks if used improperly or without understanding of the risks of hunting and travelling in the Arctic environment (Aporta and Higgs, 2005, Bravo, 2008, Ford & Pearce et al., 2008, Pearce, 2005, Pearce et al., 2009, Pearce et al., 2006). As has been observed in other contexts, technology does not reduce vulnerability unless institutions, communities and individuals know how use and adapt technology effectively. The need for enhanced training in such technologies as part of broader skills development is noted below.

6.2.1.2 Training

Across Inuit regions, research has documented a weakening of traditional environmental knowledge and land skills among younger generations (Aporta, 2004, Aporta and Higgs, 2005, Bravo, 2008, Collings et al., 1998, Ford et al., 2006, Myers et al., 2004). This trend is increasing the danger of harvesting and travel among younger generations and exacerbating the negative implication of climate change. Traditional knowledge is important for identifying and managing climatic risks and adapting to change (Berkes and Jolly, 2002, Ford, 2006, Furgal and Prowse, 2008, Seguin, 2008). There is widespread concern among community leaders that today's youth will not have the skills to adapt to future climate change, increasing the potential for loss of life and injury (Ford et al., 2007, Pearce, 2009b).

It is increasingly recognized in both the general climate change and Arctic literature, that traditional environmental knowledge (TEK) is invaluable as a basis for developing adaptation

strategies in response to environmental change (Furgal and Prowse, 2008, IPCC, 2007a, Kelman and van Dam, 2008, Turner & Clifton, , 2009). Policies that promote and facilitate the generation and transmission of TEK are central to reducing risks in a changing climate, and have the potential to increase safe hunting practices among vulnerable groups, targeting three important aspects of reducing climate-related risks: prevention, preparedness, and response.

TEK and land-skills will remain essential to managing and taking advantage of changing conditions: while climate change is undermining some aspects of traditional knowledge including the ability to forecast weather conditions, predict animal migrations, and understand environmental conditions based on place names, other skills are even more important in light of the risks (e.g. ability to identify hazard precursors, survival skills and mentality, knowledge of animal behavior etc). Moreover, research has illustrated how the experiential nature of TEK has underpinned social learning to mange emerging risks with climate change (Ford, 2009a, d). Cultural programs which provide land skills training are offered in an *ad hoc* fashion in communities across the North (Takano, 2004). The school system in Inuit regions, for example, has cultural programming as part of the curriculum, although locally these programs are often believed to be inadequate in developing necessary land skills. Some communities offer 'land camps' for young people. Since 1992, for example, Igloolik's Inullariit Society has organized land skills training camps where experienced hunters take younger generations "on the land" for weeks at a time to train them in skills such as navigating, recognizing and preparing for various hazards, identifying snow formations, and predicting weather (Takano, 2004). Training in non-traditional skills, which includes firearm safety and vehicle management, is also important in these programs. Teaching replicates the way in which knowledge and values were traditionally developed: learning by doing, watching, and being on the land (Bravo, 2008). Important safety lessons for hunting and traveling are passed on to younger Inuit in these sessions. Addressing the erosion of traditional skills through the creation of cultural schools / land skills programs should be part of a broader program in northern regions to place emphasis on skills training and development so that Inuit are better prepared to adapt to and take advantage of climate change alongside new economic opportunities (Duerden et al., In Press, Fast, 2005, Schlag and Fast, 2005). This is particularly important given the demographics of Canadian Inuit communities, where young populations will be entering the workforce and beginning to engage in harvesting activites as the effects of climate change become pronounced.

6.2.1.3 Improved hazard forecasting

Inuit hunters, particularly the younger generations who do not have the detailed understanding of the environment, make regular use of weather forecasts provided on the radio. Some individuals also make use of sea ice maps and forecasts from the Internet when making decisions about where and when to hunt (Bravo, 2008, MSC, 2004). Improving access to climate and weather information is important so people can make the decisions about where to hunt and fish during times of uncertainty (Nickels et al., 2006, Paci, 2004, White et al., 2007). At present, the quality of forecasting in Arctic Canada is limited: only four meteorologists cover Canada's Arctic region (an area larger than western Europe) and are unable to provide regularly updated weather forecasts that hunters need in a changing climate (Picco, 2007). Additionally, these meteorologists are not based in the Arctic, but in Winnipeg, and base their predictions upon synoptic satellite charts with limited availability of higher resolution localized data.

Communities across the North regularly complain about the unreliability of forecasts and potential safety implications. Enhancing forecast quality is essential in the context of climate change which is challenging the ability of experienced hunters to predict the weather using their traditional knowledge (Fox, 2004, Gearheard et al., 2006, Nickels et al., 2006, Pearce, 2009b). Moreover, improved understanding of how Inuit use and access forecasts, and developing means of improving delivery is also needed, if we are to develop forecasting products which are important to local needs.

6.2.1.4 Search and rescue

Travelling and harvesting in the Arctic environment is inherently dangerous for even the most knowledgeable and skilled individuals. Oral history is replete with examples of hunters never returning from trips and epic tales of survival (Brody, 1976, Brody, 1987). Even in absence of climate change, accidents involving falling through thin ice, getting stranded on drifting ice, or being affected by bad weather, are common (Bravo, 2008, Ford & Pearce et al., 2008). Non-climate related incidents including mechanical failure and getting lost are also common. Beginning in the 1980s, formal search and rescue (S&R) procedures were developed across the Canadian Arctic to provide emergency support and rescue where needed. Jurisdiction for S&R is currently divided between the Canadian Coast Guard, the military (including the Canadian Rangers), Royal Canadian Mounted Police (RCMP), regional/territorial government departments, and municipalities. Formal search and rescue compliments the more informal search teams that are mobilized locally when a person is missing or requires help. The current system involving both formal and informal response is widely believed to be effective among both community members and government officials (Breton-Honeyman, 2008). Local search teams are rapidly mobilized when required and involve the participation of skilled local hunters and elders; the more formal search and rescue operations are engaged when additional air, ground, and logistical support is required. Moreover, both formal and informal search organizations regularly review recent operations, identifying strengths and weaknesses of current rescues (Minogue, 2005) (Zebedee pers:comm).

Climate change, however, presents a number of challenges to S&R. Firstly, there is potential for new challenges which search and rescue organizations have limited experience. These challenges may stress the ability to respond if there is a lack of clearly delineated responsibilities and authorities among levels of government. For example, increased opportunity for commercial and tourist ships with longer ice free open water period in the summer will increase the potential for marine emergencies (Stewart et al., 2007). Jurisdiction of responsibility in responding to marine emergencies are not well specified (Zebedee pers:comm.). Secondly, search-and-rescue efforts are becoming more frequent and more dangerous, increasing the chance of injury and even loss of life (Furgal and Prowse, 2008). In 2005, for instance, two local rescuers died while searching for a lost hunter in a Nunavut community. Thirdly, in the context of de-skilling among today's younger generations, there is concern that the ability and effectiveness of local rescue teams could be compromised. Moreover, S&R operations often involve considerable risk to those involved and time commitment; in the context of weakening social networks and emerging conflict between community members noted in some Inuit communities, fewer people may be inclined or available to be involved in local operations (Ford et al., 2007). In larger communities such as Iqaluit (population 7000), Nunavut, a common complaint is a lack of local people willing

or available for search and rescue operations. Notwithstanding, new opportunities are also emerging. In recent years with resource development in Inuit regions, mining companies have provided helicopters air time to help with search operations. Additionally, GIS and GPS offer new tools for S&R coordination and have been effectively used in searches across the North (Harlow, pers:comm.; Zebedee, pers:comm.).

In the context of these challenges and opportunities it is important that S&R capability and institutional arrangements be continually reviewed as the frequency, scope, and intensity of climate related risks and impacts change as result of climate change. In particular, joint planning exercises between the different organizations involved in search and rescue including local, territorial and federal decision makers are required to identify weaknesses and strengths in current search and rescue capability. Additionally, drills and exercises, training of local search and rescue personnel, provision of safety equipment to rescuers, and worse case contingency planning are required. There is evidence that this is already occurring; Nunavut is in the process of setting up the Nunavut Search and Rescue Association which will manage $500,000 per year for equipment and training, and is currently updating its search and rescue procedures (Zebedee pers:comm.). S&R personnel and planners also need to be aware of potential implications of climate change to S&R and review current procedures in light of climate predictions. In this area, formal and informal search and rescue are less prepared (Bird, 2009). Moreover, the potential for new technology including GPS, GIS, satellite phones, and personal locator beacons, to enhance the safety and effectiveness of S&R needs to be examined. Importantly, training of local search personnel in the correct use of these technologies is essential.

6.2.2 Food security

Climate change is compromising the right of Inuit to lead healthy lives through its effects on food security. In all Inuit regions of Canada, research has documented constrained access, availability, and quality of traditional foods due to climate change (Chan, 2006, Chan et al., 2006, Ford, 2009c, b, Furgal and Seguin, 2006, Guyot et al., 2006, Nickels et al., 2006, Pearce, 2009a, b, Seguin, 2008). While offsetting traditional foods with food from the store is an acceptable option for some community members, particularly the young and those involved in the waged economy, for hunting households traditional foods are preferred because they are believed to be tastier, healthier, and have cultural significance. Moreover, any decline in traditional food consumption is a concern from the point of view of dietary health, particularly if healthy traditional foods are replaced by high fat nutrient poor store foods (Young and Bjerregaard, 2008). Additionally, for many households store foods are expensive and often not affordable to those without jobs (Damman et al., 2008). For instance, a family of four would spend between $250 and $300 to buy foods for a basic nutritious diet in isolated Nunavut communities compared to $140 to $160 in southern Canada and average incomes are significantly lower (INAC, 2006). High levels of baseline food insecurity in Inuit regions are likely to exacerbate the food security implications of climate change (Ford and Berrang-Ford, 2009, Lawn and Harvey, 2003, Ledrou and Gervais, 2005). In the context of social-economic and climatic constraints, the federal government has obligations under international human rights law (e.g. International Covenant on Economic, Social and Cultural Rights) to ensure Inuit food security is upheld (Damman et al., 2008).

Strengthening the ability of Inuit food systems to meet present dietary and nutritional requirements will increase the adaptability of the food system in a changing climate. Policy entry points suggested in the literature include: subsidization of healthy store foods, development of food-banks, extension of the food mail program to include traditional foods, organized community hunts, strategies to improve the distribution of traditional foods between communities, strengthening food sharing relationships in communities, harvester support, the development and reinstatement of community freezers, and initiatives to develop commercial ventures based around traditional foods (Boult, 2004, Chan et al., 2006, Damman et al., 2008, Ford, 2009c, Lambden et al., 2006, Myers et al., 2004, White et al., 2007). A number of successful initiatives are helping Inuit meet their dietary requirements including harvester support programs, food donations, and community freezers, although communities have made it clear that more extensive programming and government support is needed (Chan et al., 2006, Ford, 2009c). Notwithstanding these potential policy opportunities, research is only beginning to analyze how food systems might be affected by climate change in the North. Assessing vulnerability of Inuit food systems to climate change and assessing and evaluating adaptation options is a priority for future research (Chan, 2006, Furgal and Prowse, 2008, Seguin, 2008).

6.3 Promoting adaptation to the effects of climate change on personal property

A trend of increasing damage and loss of expensive hunting equipment with climate change has been documented across Inuit regions, compromising the right of Inuit to enjoy personal property (UN 1948, article 17). Particularly for hunting households, loss or damage to equipment can result in temporary or permanent loss of livelihood due to the cost of repairing or replacing damaged equipment. Furthermore, few Inuit have insurance on their hunting equipment due to a combination of high premiums, distance and lack of financial institutions in the North, limited availability of policies in northern regions, and cultural norms (Ford et al., 2007). Regional governments offer disaster compensation in some instances but this is widely regarded as insufficient, and claims can expect to increase with climate change (Ford et al., 2007). Increasing funding for disaster compensation and/or developing insurance schemes for harvesters should be a priority for government planning in a changing climate. Efforts at providing financial support to help recovery after a climate related loss should also be coordinated with targeted education campaigns to make people aware of climate change risks. Otherwise, as McLeman and Smit note (2005), insurance can create moral hazard by encouraging risk taking behaviour, thereby increasing sensitivity to climate related hazards.

6.4 Promoting adaptation to the effects of climate change on community viability

Community viability depends on a sense of place and historical attachment, and the quality of the physical fabric (e.g. houses, roads, community buildings) of a community. Both are sensitive to climate change, with the majority of Inuit cultural sites (graveyards, hunting camps etc) and current settlements located on the coast and/or on permanently frozen land (i.e. permafrost). Climate change has the potential to threaten Inuit rights to their homelands (UN, 2007 articles 10, 26) through sea level rise, coastal erosion, permafrost thaw, and more active slope processes.

Physical interventions are being considered in vulnerable communities across the Arctic to protect infrastructure. These include moving buildings, raising buildings, and installing

engineering structures to provide protection from wave action and permafrost thaw (Couture, 2003, Duerden et al., In Press, Larsen et al., 2008). Any engineering-based measures, however, will be costly and will involve trade-offs between cultural benefits and economic cost in communities and regions with limited economic means. For example, Hoeve et al (2006) conservatively estimate infrastructure related adaptation costs for the Northwest Territories to be $420m. Moreover, as Duerden et al (In Press) note, access to local gravel deposits are essential for infrastructural developments yet not all communities have access, the availability of this important resource is limited, and at present the resource is un-managed. Importing gravel from elsewhere would be costly given the costs and difficulties of Arctic transportation. Recently announced federal funding under the government's Building Canada long-term infrastructure fund will help 'climate proof' key infrastructure, although cultural sites are not covered by this fund. Documenting cultural sites at risk with climate change, identifying adaptation options and needs, and establishing funds to help protect them should all be a priority to support Inuit adaptation and protect the inviolability of the home (Nickels et al., 2006).

Relocation of some communities (e.g. Tuktoyaktuk) maybe inevitable for settlements threatened by sea level rise and accelerated coast erosion. The fate of Inupiaq community of Kivalina in Alaska which has decided it will have to relocate if the community is to survive is a portent for potential future threats affecting communities along Canada's Arctic coastline (Barringer, 2008). The costs of relocation will be extremely high although they will likely be less than protecting communities at all cost. For example, the Canadian government conservatively estimated a cost of $50m to relocate the community to Tuktoyaktuk (pop: 900). Political challenges of relocation will be considerable. The current location of the majority of Inuit communities in Arctic Canada reflects church, trading post, and government policy in the 1950s and 60s which sought to sedentarize semi-nomadic Inuit hunting groups through the provision of housing, health care and education. Many of the communities that were developed this way were located significant distances from traditional Inuit hunting areas, with many Inuit reluctant to move (Damas, 2002). Significant acculturative stress was associated with relocation and thoughts of relocation again raise bad memories for many Inuit in the North (Tester and Irniq, 2008). Notwithstanding, relocation could provide opportunity for some communities to relocate closer to traditional hunting grounds or to locations more suited to altered wildlife regimes and accessibility in a changed climate.

7 Discussion

It is now widely accepted that climate change is occurring in the Arctic and that dramatic changes can be expected in the future. Inuit are highly adaptable to climatic variability, change, and extremes. However, financial, institutional, and knowledge constraints are currently limiting adaptive capacity and increasing exposure and sensitivity to climate change effects. A number of priority areas exist for addressing these constraints, including: supporting the teaching and transmission of traditional skills, enhancing and reviewing emergency management capability, ensuring the flexibility of resource management regimes, economic support to facilitate adaptation for groups with limit household income, increased research effort to identify short and long term risk factors and adaptive response options, and promotion of awareness of climate change impacts and adaptation among the policy making community. It is noteworthy that many of these recommendations, while explored here in the context of adaptation to climate change,

also concern ongoing policy initiatives and priorities in areas of economic, social, and cultural development, and can bring immediate benefits in the form of reduced vulnerability to current climatic variability, change, and extremes. What is new is that these policy goals are re-emerging in the unique context of climate change. As such, there is agreement among many scholars and policy makers that 'mainstreaming' or 'normalizing' climate change adaptation into policies intended to broadly enhance adaptability to risk is likely to be the most effective means of reducing vulnerability to climate change (Dovers, 2009, Giddens, 2009).

Dealing with the many barriers to effective adaptation and creating an enabling environment for reducing Inuit vulnerability will require a comprehensive and dynamic portfolio of approaches covering a range of scales and issues. However, two main general strategies for climate change adaptation policy can be discerned: 1). Enhancing existing adaptive strategies; and 2). Introduction of new strategies.

Firstly, Inuit communities are autonomously adapting to climate change, mostly using behavioural and technological adaptive strategies. Many of these responses have been reactive in nature, although there is emerging evidence of proactive planning, particularly in the subsistence hunting sector. Accumulated knowledge and experience of managing climatic extremes and variability, for instance, is structuring individual, household and community decision making and resource and risk management, allowing communities to take advantage of changing conditions and reduce the negative effects. This knowledge base will help moderate vulnerability to future climate change. However, while many of these autonomous adaptations have been effective, there are good reasons to believe that autonomous adaptation has limits. Intervention by different levels of government is necessary to enhance existing climate risk management strategies and create an enabling environment for adaptation. Given that climate change will be expressed via changes in climatic variability, adaptation policy targeted at reducing vulnerability to current climatic risks will inherently help reduce vulnerability to future climate change.

Financial resources are an important component of the means to adapt, and are one of the main barriers preventing Inuit from adapting; financial barriers have also been widely noted in the literature in different geographic contexts (Heltberg, 2009, Leary et al., 2008, Patt, 2008). Many adaptations are costly and exceed the financial ability of Inuit households, communities, regional governments, and land claims institutions. Establishing funds and procedures accessible to vulnerable groups and regional governments in advance of future climate change is essential to helping Inuit maintain their livelihoods and culture in a changing climate. To this end, the Canadian State has obligations as a signatory to the FCCC, from human rights law, and through the Canadian Charter to commit resources to support adaptation (Bravo, 2008, Ford, 2009a). Notwithstanding, formidable barriers exist to achieving adaptation support. As non-state actors, Inuit do not have recourse to international legal institutions that enforce international treaties and adaptation funds through the FCCC are targeted at the least developed countries (Budreau and McBean, 2007). Theoretically, as a party to the FCCC, Canada is legally obliged to ''cooperate in preparing for adaptation to the impacts of climate change….'' although, Budreau and McBean (2007) note that a state's legal obligation to adaptation in the FCCC remain vague (e.g. what is "adequate adaptation") and are largely limited to publishing policy documents and official statements.

While adaptation assistance will inevitably require financial support, other options involve assessing the effectiveness of current policies and programs in the context of a changing climate, developing institutional capacity, improving the decision making environment, and integrating climate change into long term strategic planning. One of the main challenges here is institutional capacity. All levels of governance in northern Canada experience high staff turn-over and maintaining intuitional memory and strategic long term planning is challenging in this context (Bird et al., 2008, Duerden and Beasley, 2006, Myers et al., 2004). Moreover, as Schlag and Fast (2005) note in the Inuvialuit Settlement Region, many of today's younger generations are believed to be not ready to assume leadership responsibilities as older generations retire; an observation noted in other regions of Canada's north and a major challenge to overcome (Furgal, 2008).

Secondly, future climate change will require forward looking investment and planning responses to address risks to which communities and institutions in the north have limited experience with. This is particularly pertinent for the implications of future warming on geomorphologic process and associated infrastructural impacts, where the full impacts of climate change are not yet discernible. It is likely that it is more cost-effective to develop adaptations early on, especially for infrastructure with long economic life and to incorporate climate change into impact assessments and community planning (Hallegatte, 2009, Larsen et al., 2008, Stern, 2006). Moreover, current understanding of the implications of surprise and changes outside the range of current experience, and potential adaptive options remains limited.

Finally, developing and implementing adaptation policy is not an endpoint in itself but an ongoing process that is part of good risk management, where drivers of vulnerability are identified, monitored, and the effectiveness of policy response continually evaluated over time. This is particularly important with regard to climate change in the Arctic, where polar amplification and crossing of thresholds may accelerate climate change impacts in ways not currently understood (Lenton et al., 2008), and rapidly socio-economic-demographic conditions alter the context within which climate change occurs and is experienced. Moreover, monitoring climate change vulnerability and adaptation over time is also essential, as vulnerability is inherently dynamic, changing as the communities and the climate changes. To this end, community monitoring across the Arctic is needed to identify emerging threats and new opportunities, and should compliment long term scientific projects.

8 Conclusion

Adaptation is needed to protect livelihoods in a changing climate. This is particularly the case for Canada's Inuit regions where climate change could already be defined as "dangerous," is challenging Inuit human rights, and is compromising the specific rights of Inuit as stated in the Canadian Charter. Acting now on adaptation can bring near-term benefits, reduce current climate vulnerability, and target socio-economic policy objectives alongside managing the effects of current and future climate change. Yet political action and lobbying by Inuit political actors (including Inuit politicians, politicians representing Inuit in regional and national governments, Inuit organizations), and supported by the NGO community, remains dominated by a focus on illustrating the impacts of climate change and arguing for mitigation. Scientific research meanwhile has largely focused on documenting climate change vulnerabilities but has rarely

taken the next step to identify policy options. This is insufficient in light of the vulnerability of Inuit populations, current experience of climate change, and future climate change projections. In this paper we have identified opportunities for adaptation policy development. While our recommendations are not exhaustive and are largely confined to the traditional resource use sector, we have hopefully started the debate on how adaptation policy can reduce Inuit vulnerability to climate change.

References

Aarluk Consulting. (2005) A Consultation-Based Review of the Harvester Support Programs of the Government of Nunavut and Nunavut Tunngavik Inc. Iqaluit, Nunavut Aarluk Consulting.

ACIA (2005) Arctic Climate Impacts Assessment. Cambridge, UK, Cambridge University Press.

Adger, W.N. (2006) Vulnerability *Global Environmental Change,* 16**,** 268-281.

Adger, W.N., Kelly, P.M. & Ninh, N.H. (2001) *Living with Environmental Change: Social Resilience, Adaptation, and Vulnerability in Vietnam*, Routledge, London.

AHDR (2004) Arctic Human Development Report. Akureyri, Iceland, Stefansson Arctic Institute.

Alessa, L., Kliskey, A., Busey, R., Hinzman, L. & D. White (2008) Freshwater vulnerabilities and resilience on the Seward Peninsula: Integrating multiple dimensions of landscape change. *Global Environmental Change-Human and Policy Dimensions,* 18**,** 256-270.

Alessa, L., Kliskey, A., Williams, P., & Barton, M. (2008) Perception of change in freshwater in remote resource-dependent Arctic communities. *Global Environmental Change,* 18**,** 153-164.

Andrachuk, M. (2008) An Assessment of the Vulnerability of Tuktoyaktuk to Environmental and Socio-Economic Changes. *Department of Geography*. Guelph, University of Guelph.

Aporta, C. (2004) Routes, trails and tracks: Trail breaking among the Inuit of Igloolik. *Inuit Studies,* 28**,** 9-38.

Aporta, C. & Higgs, E. (2005) Satellite culture: Global Positioning Systems, Inuit wayfinding, and the need for a new account of technology. *Current Anthropology,* 46**,** 729-753.

Armitage, D., & Clark, D. (2005a) Issues, priorities and research directions for oceans management in Canada's North. IN F. Berkes, R. H., H. Fast, M. Manseau, and A. Diduck (Ed.) *Breaking Ice: Renewable Resource and Ocean Management in the Canadian North.* Calgary, Canada, University of Calgary Press.

Armitage, D., Marschke, M. & Plummer, R. (2008) Adaptive co-management and the paradox of learning. *Global Environmental Change,* 18**,** 86-98.

Armitage, D.R. (2005b) Community-Based Narwhal Management in Nunavut, Canada: Change, Uncertainty, and Adaptation. *Society and Natural Resources,* 18**,** 715-731.

Barber, D.G., Lukovich, J.V., Keogak, J., Baryluk, S., Fortier, L. & Henry, G.H.R. (2008) The Changing Climate of the Arctic. *Arctic,* 61**,** 7-26.

Barringer, F. (2008) Flooded Village Files Suit, Citing Corporate Link to Climate Change *The New York Times*

Berkes, F., Berkes, M.K. & Fast, H. (2007) Collaborative integrated management in Canada's north: The role of local and traditional knowledge and community-based monitoring. *Coastal Management,* 35**,** 143-162.

Berkes, F., Huebert, R., Fast, H., Manseau, M., and A. Diduck, (Ed.) (2005) *Breaking Ice: Renewable Resource and Ocean Management in the Canadian North*, Calgary, University of Calgary Press.

Berkes, F. & Jolly, D. (2002) Adapting to climate change: Social-ecological resilience in a Canadian Western Arctic community. *Conservation Ecology,* 5**,** [online] http://www.consecol.org/vol5/iss2/art18/.

Bird, J. (2008) Feds tried to bypass Inuit on polar bears. *Nunatsiaq News.* Iqaluit.

Bird, J. (2009) Polar Year Brought New Money to Nunavut. *Nunatsiaq News.* Iqaluit.

Bird, S.M., J.L., W., Okalik, L., Kilabuk, J. & Egeland, G. (2008) Living with diabetes on Baffin Island. *Canadian Journal of Public Health***,** 17-21.

Blaikie, P., Cannon, T., Davis, I. & B. Wisner (1994) *At Risk: Natural Hazards, People's Vulnerability and Disasters*, New York, Routledge.

Boult, D.A. (2004) Hunger in the Arctic: Food (in)security in Inuit communities Ajunnginiq Centre, National Aboriginal Health Organization

Bouwer, L.M. & Aerts, J.C.J.H. (2006) Financing climate change adaptation. *Disasters,* 30**,** 49-63.

Bravo, M. (2008) Sea ice mapping: ontology, mechanics, and human rights at the floe edge. IN Cosgrove, D., & Della Dora, V. (Ed.) *High Places: Cultural Geographies of Mountains, Ice and Science.* London, I. B. Tauris.

Breton-Honeyman, K., & Furgal, C. (2008) Climate Change, Public Health and Safety in the Arctic: An investigation of Inuit vulnerability and resilience through land based safety and search and rescue efforts in the Inuvialuit Settlement Region, NWT Canada.

Brody, H. (1976) Inummariit: The real Eskimos. IN Freeman, M. R. (Ed.) *Inuit land use in northern Baffin Island and northern Foxe Basin.* Ottawa, Thorn Press Limited.

Brody, H. (1987) *Living Arctic: Hunters of the Canadian North*, London, Faber and Faber.

Brunner, R., Steelman, T. A., Coe-Juell, L., Cromley, C. M., Edwards, C. M., & Tucker, D. W. (Eds.) (2005) *Adaptive governance: Integrating science, policy, and decision-making*, New York, Columbia University Press.

Budreau, D. & McBean, G. (2007) Climate change, adaptive capacity and policy direction in the Canadian North: Can we learn anything from the collapse of the east coast cod fishery? *Mitigation and Adaptation Strategies for Global Change,* 12**,** 1305-1320.

Burek, K.A., Gulland, F.M.D. & O'Hara, T.M. (2008) Effects of climate change on Arctic marine mammal health. *Ecological Applications,* 18**,** S126-S134.

Burton, I. & Lim, B. (2005) Achieving adequate adaptation in agriculture. *Climatic Change,* 70**,** 191-200.

Chan, H.M. (2006) Food safety and food security in the Canadian Arctic. *Meridian*, Fall/Winter**,** 1-4.

Chan, H.M., Fediuk, K., Hamilton, S.E., Rostas, L., Caughey, A., Kuhnlein, H.V., Egeland, G. & Loring, E. (2006) Food security in Nunavut, Canada: Barriers and recommendations. *International Journal of Circumpolar Health,* 65**,** 416-431.

Chapin, F.S. (2006) Building resilience and adaptation to manage arctic change. *Ambio,* 35**,** 198-202.

Chapin, F.S., Lovecraft, A.L., Zavaleta, E.S., Nelson, J., Robards, M., Kofinas, G., Trainor, S., Peterson, G.D., Huntington, H. & Naylor, R.L. (2006) Policy strategies to address sustainability of Alaskan boreal forests in response to a directionally changing climate. *Proceedinds of the National Academy of Sciences,* Early Edition**,** 1-7.

Chapin, F.S., Peterson, G., Berkes, F., Callaghan, T.V., Angelstam, P., Apps, M., Beier, C., Bergeron, Y., Crepin, A.S., Danell, K., Elmqvist, T., Folke, C., Forbes, B., Fresco, N., Juday, G., Niemela, J., Shvidenko, A. & Whiteman, G. (2004) Resilience and vulnerability of northern regions to social and environmental change. *Ambio,* 33**,** 344-349.

Clark, D., Lee, D.S., Freeman, M.M.R. & Clark, S.G. (2008) Polar bear conservation in Canada: Defining the policy problems. *Arctic*

Collings, P. (1997) Subsistence hunting and wildlife management in the central Canadian arctic. *Arctic Anthropology,* 34**,** 41-56.

Collings, P., Wenzel, G. & Condon, R.G. (1998) Modern food sharing networks and community integration in the Central Canadian Arctic. *Arctic,* 51**,** 301-314.

Comiso, J.C., Parkinson, C.L., Gertsen, R. & Stock, L. (2008) Accelerated decline in the Arctic sea ice cover. *Geophysical Research Letters,* 35.

Corell, R.W. (2006) Challenges of climate change: An Arctic perspective. *Ambio,* 35**,** 148-152.

Couture, R., Smith, S., Robinson, S.D., Burgess, M.M., & Solomon, S. (2003) On the Hazards to Infrastructure in the North Associated with Thawing of Permafrost. *Third Canadian Conference on Geotechnique and Natural Hazards.* Edmonton.

Crump, J. (2008) Many strong voices: Climate change and equity in the Arctic *Indigenous Affairs* 1-2**,** 24-33.

Damas, D. (2002) *Arctic Migrants / Arctic Villagers,* McGill-Queens University Press.

Damman, S., Eide, W.B. & Kuhnein, H.V. (2008) Indigenous peoples' nutrition transition in a right to food perspective. *Food Policy,* 33**,** 135-155.

Derocher, A., Lunn, N.J. & Stirling, I. (2004) Polar bears in a warming climate. *Integrative Comparative Biology,* 44**,** 163-176.

Dorais, L.J. (1997) *Quaqtaq: modernity and identity in an Inuit community.,* Toronto, University of Toronto Press.

Dovers, S. (2009) Normalizing adaptation. *Global Environmental Change,* 19**,** 4-6.

Dowsley, D. & Wenzel, G. (2008) "The time of most polar bears": A co-management conflict in Nunavut. *Arctic,* 61**,** 177-189.

Dowsley, M. (2009) Community clusters in wildlife and environmental management: using TEK and community involvement to improve co-management in an era of rapid environmental change. *Polar Research,* 28**,** 43-59.

Duerden et al. (In Press) Assessing Community Vulnerabilities to a Changing Environment in the Inuvialuit Settlement Region.

Duerden, F. (2004) Translating climate change impacts at the community level. *Arctic,* 57**,** 204-212.

Duerden, F. & Beasley, E. (2006) Assessing community vulnerabilities to environmental change in the Inuvialuit region IN Riewe, R. & Oakes, J. (Eds.) *Climate Change: Linking Traditional and Scientific Knowledge.* Winnipeg, Manitoba, Aboriginal Issues Press.

Ebi, K.L. & Semenza, J.C. (2008) Community-Based Adaptation to the Health Impacts of Climate Change. *American Journal of Preventive Medicine,* 35**,** 501-507.

Fast, H., Chiperzak, D., Cott, K., & Elliott, G.M. (2005) Integrated management planning in Canada's western Arctic: An adaptive consultation process. IN F. Berkes, R. H., H. Fast, M. Manseau, and A. Diduck (Ed.) *Breaking Ice: Renewable Resource and Ocean Management in the Canadian North.* Calgary, University of Calgary Press.

FCCC (1992) United Nations Framework Convention on Climate Change - Convention Text. IUCC, Geneva.

Ford, J.D. (2006) Vulnerability to climate change in Arctic Canada. *Department of Geography.* Guelph, University of Guelph.

Ford, J.D. (2008a) Climate, society, and natural hazards: Changing hazard exposure in two Nunavut communities. *Northern Review,* 28**,** 51-71.

Ford, J.D. (2008b) Emerging trends in climate change policy: The role of adaptation. *International Public Policy Review,* 3**,** 5 – 15

Ford, J.D. (2008c) Supporting Adaptation: A priority for action on climate change for Canadian Inuit. *Sustainable Development Law & Policy* 8**,** 25-31.

Ford, J.D. (2009a) Dangerous climate change and the importance of adaptation for the Artic's Inuit population. *Environmental Research Letters,* 4**,** 1-9.

Ford, J.D. (2009b) Vulnerability of Inuit food systems to food insecurity as a consequence of climate change: A case study from Igloolik, Nunavut. *Regional Environmental Change,* 9**,** 83-100.

Ford, J.D., & M. Beaumier (2009c) Climate Change and Food Security among Females in an Inuit Community. *Pauktuutit Inuit Women of Canada. Inuit Women and Climate Change.*

Ford, J.D. & Berrang-Ford, L. (2009) Food security in Igloolik, Nunavut: A baseline study. *Polar Record,* 45**,** 225-236.

Ford, J.D. & Furgal, C. (2009) Climate change impacts, adaptation and vulnerability in the Arctic. *Polar Research.*

Ford, J.D., Gough, B., Laidler, G., MacDonald, J., Qrunnut, K, and Irngaut, C. (2009d) Sea ice, climate change, and community vulnerability in northern Foxe Basin, Canada. *Climate Research,* 37**,** 138-154.

Ford, J.D., MacDonald, J., Smit, B. & Wandel, J. (2006) Vulnerability to climate change in Igloolik, Nunavut: What we can learn from the past and present. *Polar Record,* 42**,** 1-12.

Ford, J.D., Pearce, T., Gilligan, J., Smit, B. & J. Oakes (2008) Climate change and hazards associated with ice use in Northern Canada. *Arctic, Antarctic and Alpine Research,* 40**,** 647-659.

Ford, J.D., Pearce, T., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusujurat, H. & Qrunnut, K. (2007) Reducing vulnerability to climate change in the Arctic: the case of Nunavut, Canada. *Arctic* 60**,** 150-166.

Ford, J.D. & Smit, B. (2004) A framework for assessing the vulnerability of communities in the Canadian Arctic to risks associated with climate change. *Arctic,* 57**,** 389-400.

Ford, J.D., Smit, B., Wandel, J., Allurut, M., Shappa, K., Ittusarjuat, H. & Qrunnut, K. (2008) Climate change in the Arctic: current and future vulnerability in two Inuit communities in Canada. *Geographical Journal,* 174**,** 45-62.

Fox, S. (2004) When the weather is Uggianaqtuq: Linking Inuit and scientific observations of recent environmental changes in Nunavut, Canada. Boulder, University of Colorado.

Furgal, C., et al, (2008) Health Impacts of Climate Change in Canada's North. IN Séguin, J. (Ed.) *Human Health in a Changing Climate: A Canadian Assessment of Vulnerabilities and Adaptive Capacity.* Health Canada.

Furgal, C., Innes, S. & Kovacs, K.M. (2002) Inuit spring hunting techniques and local knowledge of the ringed seal in Arctic Bay (Ikpiarjuk), Nunavut. *Polar Research,* 21**,** 1-16.

Furgal, C. & Prowse, T. (2008) Northern Canada IN Lemmen, D., Warren, F., Bush, E. & Lacroix, J. (Eds.) *From Impacts to Adaptation: Canada in a Changing Climate 2007.* Ottawa Natural Resources Canada.

Furgal, C. & Seguin, J. (2006) Climate change, health, and vulnerability in Canadian Northern Aboriginal communities. *Environmental Health Perspectives* 114**,** 1964-1970.

Gearheard, S., Matumeak, W., Angutikjuaq, I., Maslanik, J.A., Huntington, H., J., L., Matumeak, D., G., T. & Barry, R.G. (2006) "It's not that simple": Comparison of sea ice environments, observed changes, and adaptations in Barrow Alaska, USA, and Clyde River, Nunavut, Canada. *Ambio,* 35**,** 203-211.

George, J. (2006a) Global warming won't hurt polar bears, GN says. *Nunatsiaq News.* Iqaluit.

George, J. (2006b) Hunters need one-stop funding shop *Nunatsiaq News.* Iqaluit.

Giddens, A. (2009) *The Politics of Climate Change,* Polity Press.

Gombay, N. (2007) From subsistence to commercial fishing in Northern Canada - The experience of an Inuk entrepreneur *British Food Journal,* 108**,** 502-521.

Graversen, R.G., Mauritsen, T., Tjernstrom, M., Kallen, E. & Svensson, G. (2008) Vertical structure of recent Arctic warming. *Nature,* 451**,** 53-U4.

Guyot, M., Dickson, C., Paci, C., Furgal, C. & Chan, H., . (2006) Local observations of climate change and impacts of traditional food security in two northern aboriginal communities. *International Journal of Circumpolar Health,* 65**,** 403-415.

Hallegatte, S. (2009) Strategies to adapt to an uncertain climate change. *Global Environmental Change,* In Press, Corrected Proof.

Healey, G. & Meadows, L. (2007) Inuit women's health in Nunavut, Canada: A review of the literature. *International Journal of Circumpolar Health,* 66**,** 199-214.

Health Canada (2008a) Adapting to the Health Impacts of Climate Change. Ottawa, Health Canada.

Health Canada (2008b) Human Health in a Changing Climate Ottawa, Health Canada

Heltberg, R. (2009) Climate change: Challenges for social protection in Africa. *Earth Environ. Sci,* 6.

Henshaw, A. (2007) Pausing along the journey: learning landscapes, environmental change and place names amongst the Sikusilarmiut. *Arctic Anthropology* 43**,** 52-66.

Hewitt, K. (1983) The idea of calamity in a technocratic age. IN Hewitt, K. (Ed.) *Interpretations of calamity from the viewpoint of human ecology.* London, Allen and Unwin.

Huntington, H., Hamilton, L., Nicholson, C., Brunner, R., Lynch, A., Ogilvie, A.E.J. & Voinov, A. (2007) Toward understanding the human dimensions of the rapidly changing arctic system: insights and approaches from five HARC projects. *Regional Environmental Change* 7**,** 173-186.

ICC (2005) Petition to the Inter American Commission on Human Rights Ottawa, Inuit Circumpolar Conference.

INAC (1996) Report of the Royal Commission on Aboriginal Peoples. Ottawa, Canada Communication Group.

INAC (2006) Weekly cost of the Northern Food Basket for a family of four, 1990-2006. *Northern Food Basket - Food Mail Program.* Ottawa, Government of Canada.

INAC (2007) Report on Adaptation to Climate Change Activities in Arctic Canada. Ottawa, Northern Affairs Program Canada: Environment and Renewable Resources.

IPCC (2007a) Climate Change 2007: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Intergovernmental Panel on Climate Change Fourth Assessment Report. Geneva.

IPCC (2007b) Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Geneva.

Kelman, I. & van Dam, K. (2008) Vulnerability and Adaptation to Climate Change in the Arctic (VACCA): An analysis of the scoping study data. A report prepared for the Sustainable Development Working Group of the Arctic Council.

Keskitalo, E.C. (2008) *Climate change and globalization in the Arctic: An integrated apporach to vulnerability assessment*, Earthscan.

Keskitalo, E.C. (2009) Governance in vulnerability assessment: the role of globalising decision-making networks in determining local vulnerability and adaptive capacity. *Mitig Adapt Strateg Glob Change,* 14**,** 185-201.

Kishigami, N. (2000) Contemporary Inuit food sharing and the hunter support program of Nunavik, Canada. IN Wenzel, G., Hovelsrud-Broda, G. & Kishigami, N. (Eds.) *The Social Economy of Sharing: Resource Allocation and Modern Hunter-Gatherers.*

Krupnik, I. (1993) *Arctic Adaptations: Native Whalers and Reindeer Herders of Northern Eurasia.,* Hanover, New Hampshire, University Press of New England.

Krupnik, I. & Jolly, D. (2002) *The Earth is Faster Now: Indigenous Observations of Climate Change,* Fairbanks, Alaska, Arctic Research Consortium of the United States.

Lafortune. V., Furgal, C., Drouin, J., Annanack, T., Etidloie, B., Einish, N., Tookalook, P., Qiisiq, M., Tremblay, M. & Kangiqsujuaq, U., Kangiqsualujjuaq and Kawawachikamach Communities (2006) Climate change in Northern Quebec and its impacts on accessibility to resources: The example of the traditional trails network. *ArcticNet Annual Conference Proceedings.*

Laidler, G. (2006) Inuit and scientific perspectives on the relationship between sea ice and climatic change: the ideal complement? *Climatic Change,* 78**,** 407-444.

Laidler, G., Ford, J.D., Gough, W.A., Ikummaq, T., Gagnon, A., Kowal, S., Qrunnut, K. & Irngaut, C. (2009) Travelling and hunting in a changing Arctic: assessing Inuit vulnerability to sea ice change in Igloolik, Nunavut. *Climatic Change,* 94**,** 363-397.

Laidler, G. & Ikummaq, T. (2008) Human geographies of sea ice: freeze/thaw processes around Igloolik, Nunavut, Canada. *Polar Record,* 44**,** 127-153.

Laidre, K. & Heide-Jorgensen, M.P. (2005) Arctic sea ice trends and narwhal vulnerability. *Biological Conservation,* 121**,** 509-517.

Laidre, K., Stirling, I., Lowry, L.F., Wiig, O., Heide-Jorgensen, M.-P. & Ferguson, S.H. (2008) Quantifying the sensitivity of arctic marine mammals to climate-induced habitat change. *Ecological Applications,* 18**,** 97-125.

Lambden, J., Receveur, O., Marshall, J. & Kuhnlein, H. (2006) Traditional and market food access in the Arctic is affected by economic factors *International Journal of Circumpolar Health,* 65**,** 331-340.

Larsen, P.H., Goldsmith, S., Smith, O., Wilson, M.L., Strzepek, K., Chinowsky, P. & Saylor, B. (2008) Estimating future costs for Alaska public infrastructure at risk from climate change. *Global Environmental Change,* 18**,** 442-457.

Lawn, J. & Harvey, D. (2003) Nutrition and Food Security in Kugaaruk, Nunavut: Baseline Survey for the Food Mail Pilot Project. Ottawa, Department of Indian and Northern Affairs

Leary, N.A., Adejuwon, J., Barros, V., Burton, I., Kulkarni, J. & Lasco, R. (Eds.) (2008) *Climate change and adaptation* London, Earthscan.

Ledrou, I. & Gervais, J. (2005) Food Insecurity Statistics Canada 2005, Catalogue number 82-003-XIE.

Leichenko, R.M. & O'Brien, K.L. (2002) The Dynamics of Rural Vulnerability to Global Change: The Case of Southern Africa. *Mitigation and Adaptation Strategies for Global Change,* 7**,** 1-18.

Lemmen, D., Warren, F., Lacroix, J. & Bush, E. (2008) From impacts to adaptation: Canada in a changing climate 2007. Ottawa, Government of Canada.

Lenton, T.M., Held, H., Kriegler, E., Hall, J.W., Lucht, W., Rahmstorf, S. & Schellnhuber, H.J. (2008) Inaugural Article: Tipping elements in the Earth's climate system.

Lynch, A.H. & Brunner, R.D. (2007) Context and climate change: An integrated assessment for Barrow, Alaska. *Climatic Change,* 82**,** 93-111.

Martin, D., Belanger, D., Gosselin, P., Brazeau, J., Furgal, C. & Dery, S. (2007) Drinking water and potential threats to human health in Nunavik: Adaptation strategies under climate change conditions. *Arctic,* 60**,** 195-202.

McLeman, R. & Smit, B. (2005) Vulnerability to climate change hazards and risks: crop and flood insurance. *The Canadian Geographer,* 50**,** 217-226.

McLoughlin, P.D., Taylor, M. & Dowsley, D. (2008) Update COSEWIC status report on the Polar Bear Committee on the Status of Endangered Wildlife in Canada

Miller, F.L. & Gunn, A. (2003) Catastrophic die off of Peary caribou on the western Queen Elizabeth Islands, Canadian High Arctic. *Arctic,* 56**,** 381-390.

Min, S.K., Zhang, X.B. & Zwiers, F. (2008) Human-Induced arctic moistening. *Science,* 320**,** 518-520.

Minogue, S. (2005) Training, prevention top agenda at search and rescue conference. *Nunatsiaq News.* Iqaluit.

Moore, S.E. & Huntington, H. (2008) Arctic marine mammals and climate change: impacts and resilience *Ecological Applications***,** S157–S165 (Supplement).

MSC (2004) Reducing the risk of hunting and fishing at the ice edge. *MSC Atmospheric and Climate Science: Research Making a Difference.* Downsveiw, Ontario, Atmospheric and Climate Science Directorate, Meteorological Service of Canada.

Myers, H., Powell, S. & Duhaime, G. (2004) Setting the table for food security: Policy impacts in Nunavut. *Journal of Native Studies,* XXIV**,** 425-445.

Nadasdy, P. (2003) *Hunters and Bureaucrats: Power, Knowledge, and Aboriginal-State Relations in the Southwest Yukon,* Vancouver, University of British Columbia Press

Natcher, D.C., Davis, S., & Hickey, C.G. (2005) Co-management: managing relationships, not resources. *Human Organization,* 64**,** 240-250.

Nelson, O. (2003) Climate change erodes Inuit knowledge, researches say. *Nunatsiaq News.* Iqaluit

Newton, J., Paci, C.D. & Ogden, A. (2005) Climate change and natural hazards in northern Canada: integrating indigenous perspectives with government policy. *Mitigation and Adaptation Strategies for Global Change,* 10**,** 541-571.

Nickels et al. (Ed.) (2006) *Unikkaaqatigiit - Putting the Human Face on Climate Change: Perspectives from Inuit in Canada,* Ottawa, Joint Publication of Inuit Tapiriit Kanatami, Nasivvik Centre for Inuit Health and Changing Environments at Universite Laval and the Ajunnginiq Centre at the Nataional Aboriginal Health Organization.

O'Brien, K., Eriksen, S., Nygaard, L.P. & Schjolden, A. (2007) Why different interpretations of vulnerability matter in climate change discourses. *Climate Policy,* 7**,** 73-88.

O'Brien, K., Sygna, L. & Haugen, J.E. (2004) Resilient or Vulnerable? A Multi-Scale Assessment of Climate Impacts and Vulnerability in Norway. *Climate Change,* 64**,** 193-225.

Paci, C. (2004) Food Security of Northern Indigenous Peopes in a Time of Uncertainty *Northern Research Forum.* Yellowknife.

Patt, A.G., Schroter, D., Vega-Leinert, A.C., & Klein, R.T (2008) Vulnerability Research and Assessment to Support Adaptation and Mitigation: Common Themes from the Diversity of Approaches. IN Patt, A. G., Schroter, D., Vega-Leinert, A.C., Klein, R.T (end (Ed.) *Assessing Vulnerabiltiy to Global Environmental Change.* London, Earthscan.

Pearce, T. (2005) Living with climate change in Ulukhaktok (Holman, NT). *Weathering Change,* Spring 2005**,** 6.

Pearce, T., Ford, J. & et al. (2009) Community collaboration and environmental change research in the Canadian Arctic. *Polar Research,* 28**,** 10-27.

Pearce, T., Ford, J., Duerden, F., & Smith T.R. (2009a) Climate change vulnerability and adaptation in the ISR: A sytematic literature review and gap analysis. Project report from the Dept. of Indian and Northern Affairs Climate Change Impacts and Adaptation Program.

Pearce, T., Smit, B., Duerden, F., Katayoak, F., Inuktalik, R., Goose, A., Ford, J. & Wandel, J. (2006) Travel Routes, Harvesting and Climate Change in Ulukhaktok, Canada. *Northern Research Forum Open Meeting – The Borderless North.* Oulu, Finland and Lulea, Sweden.

Pearce, T., Smit, B., Duerden, F., Ford, J., Goose, A., Inuktalik, R., Kataoyak, F., & Wandel, J. (2009b) 'Community Adaptation and Vulnerability to Climate Change in Ulukhaktok'. *Arctic.*

Pelling, M. (2002) Assessing urban vulnerability and social adaptation to risk - Evidence from Santo Domingo. *International Development Planning Review,* 24**,** 59-76.

Picco, E. (2007) Opening remarks to launch of the STAR project by Government of Nunavut Minister Ed Picco Iqaluit, Nunavut

Ramanathan, V. & Feng, Y. (2008) On avoiding dangerous anthropogenic interference with the climate system: Formidable challenges ahead. *Proceedings of the National Academy of Sciences of the United States of America,* 105**,** 14245-14250.

Reist, J.D., Wrona, F.J., Prowse,T.D., Power, M., Dempson, J.B., King, J.R., & Beamish, R.J. (2006) An overview of effects of climate change on arctic freshwater and anadromous fisheries. *Ambio,* 35**,** 381-387.

Riewe, R., & Oakes, J. (Ed.) (2006) *Climate Change: Linking Traditional and Scientific Knowledge,* Manitoba, Aboriginal Issues Press.

Schellnhuber, H.J. (2008) Global warming: Stop worrying, start panicking? *Proceedings of the National Academy of Sciences of the United States of America,* 105**,** 14239-14240.

Schellnhuber, H.J., Cramer, W., Nakicenovic, N., Wigely, T. & Yohe, G. (Eds.) (2006) *Avoiding Dangerous Climate Change,* Cambridge Cambridge University Press.

Schlag, M.P. & Fast, H. (2005) Marine stewardship and Canada's oceans agenda in the western Canadain Arctic: A role for yuoth. IN Berkes, F., Huebert, R., Fast, H., Mansueau, M. & Didcuk, A. (Eds.) *Breaking Ice: Renewable Resource Management in the Canadian North* Unvirstiy of Calgary Press

Schliebe, S., Rode, K.D., Gleason, J.S., Wilder, J., Proffitt, K., Evans, T.J. & Miller, S. (2008) Effects of sea ice extent and food availability on spatial and temporal distribution of polar bears during the fall open-water period in the Southern Beaufort Sea. *Polar Biology,* 31**,** 999-1010.

Seguin, J. (2008) Human Health in a Changing Climate Ottawa, Health Canada

Sen, A. (1981) *Poverty and famines: an essay on entitlement and deprivation,* Oxford, Clarendon Press.

Senécal, S. & O'Sullivan, E. (2006) The Well-Being of Inuit Communities in Canada. Ottawa Indian and Northern Affairs Canada.

Serreze, M., Holland, M.M. & Stroeve, J. (2007) Perspectives on the Arctic's shrinking sea ice cover. *Science,* 316**,** 1533-1536.

Serreze, M.C. & Francis, J.A. (2006) The Arctic amplification debate. *Climatic Change,* 76**,** 241-264.

Smit, B. & Wandel, J. (2006) Adaptation, adaptive capacity, and vulnerability. *Global Environmental Change,* 16**,** 282-292.

Stern, N. (2006) *The Economics of Climate Change: The Stern Review,* Cambridge Cambridge University Press.

Stevenson, M.G. (2006) The Possibility of Difference: Rethinking Co-management. *Human Organization,* 65**,** 167-180.

Stewart, E.J., Howell, S.E.L., Draper, D., Yackel, J. & Tivy, A. (2007) Sea ice in Canada's Arctic: Implications for cruise tourism. *Arctic,* 60**,** 370-380.

Takano, T. (2004) Connections with the land: land skills courses in Igloolik, Nunavut. *Ethnography,* 6**,** 463-486.

Tester F., P.I. (2008) Inuit Qaujimajatuqangit: Social history, politics and the practice of resistance. *Arctic,* 61**,** 48-61.

Tews, J., Ferguson, M.A.D. & Fahrig, L. (2007a) Modeling density dependence and climatic disturbances in caribou: a case study from the Bathurst Island complex, Canadian High Arctic. *Journal of Zoology,* 272**,** 209-217.

Tews, J., Ferguson, M.A.D. & Fahrig, L. (2007b) Potential net effects of climate change on High Arctic Peary caribou: Lessons from a spatially explicit simulation model. *Ecological Modelling,* 207**,** 85-98.

Thomalla, F., Downing, T., Spanger-Siegfried, E., Han, G. & Rockstrom, J. (2006) Reducing hazard vulnerability: towards a common approach between disaster risk reduction and climate adaptation. *Disasters,* 30**,** 39-48.

Tompkins, E. & Adger, W.N. (2004) Does adaptive management of natural resources enhance resilience to climate change? *Ecology and Society,* 9**,** 10. [online] http://www.ecologyandsociety.org/vol9/iss2/art10.

Tremblay, M., Furgal, C., Lafortune, V., Larrivee, C., Savard, J.P., Barrett, M., Annanack, T., Enish, N., Tookalook, P. & Etidloie, B. (2006) Communities and ice: Linking traditional and scientific knowledge. IN Riewe, R. & Oakes, J. (Eds.) *Climate Change: Linking Traditional and Scientific Knowledge.* Winnipeg, Manitoba, Aboriginal Issues Press.

Turner, N., & Clifton, H. (2009) “It's so different today”: Climate change and indigenous lifeways in British Columbia, Canada *Global Environmental Change,* 19**,** 180-190.
Tyrrell, M. (2007) At the interstices of knowledge: finding common ground in the co-management of arctic species. *ArcticNet Annual Conference Proceedings,* 1.
UN (1948) Universal Declaration of Human Rights.
UN (2007) Declaration on the rights of Indigenous peoples.
USFWS (2008) Endangered Species Program. Washington, DC, Department of the Interior.
Vilhjálmsson, H., Hoel, AH. (2005) Fisheries and aquaculture: Arctic climate impact assessment. Cambridge, Cambridge University Press.
Wenzel, G. (1991) *Animal Rights, Human Rights,* Toronto, University of Toronto Press.
Wenzel, G. (2005) Nunavut Inuit and polar bear: the cultural politics of the sports hunt. *Senri Ehtnological Studies,* 67**,** 363-388.
Wenzel, G. (2009) Canadian Inuit subsistence and ecological instability- if the climate changes, must the Inuit? *Polar Research,* 28**,** 88-89.
White, D., Gerlach, S.C., Loring, P., Tidwell, A.C. & Chambers, M.C. (2007) Food and water security in a changing arctic climate. *Environmental Research Letters,* October-December**,** 045018.
White, D.M., Gerlach, S.C., Loring, P., Tidwell, A.C., & Chambers, C. (2007) Food and water security in a changing arctic climate. *Environmental Research Letters,* 2**,** 4.
Wigely, T.M.L. (2005) The climate change committment. *Science,* 307**,** 1766-1769.
Wolfe, B.B., Armitage, D., Wesche, S., Brock, B.E., Sokal, M.A., Clogg-Wright, K.P., Mongeon, C.L., Adam, M.E., Hall, R.I. & Edwards, T.W.D. (2007) From isotopes to TK interviews: Towards interdisciplinary research in Fort Resolution and the Slave River Delta, Northwest Territories. *Arctic,* 60**,** 75-87.
Young, T.K. & Bjerregaard, P.B. (2008) *Health Transititions in Arctic Populations* Toronto University of Toronto Press.